

EUV Underlayer to Enhance Photospeed and Prevent Pattern Collapse

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Abstract: The RLS (Resolution, LER, and Sensitivity) trade-off is a considerable challenge facing EUV technology. Compared to strictly defined chemical structures in resists, underlayers can use a wide range of chemical functionalities to improve one of the three parameters independently from the other two. For example, using an underlayer with EUV sensitizers or metal component could increase the photosensitivity by 10% to 30% without obvious LWR, resolution, and depth-of-focus trade-offs. We also demonstrated that the crosslinker amount in the formulation could have a great impact on the final litho performance with regard to LWR and pattern collapse.

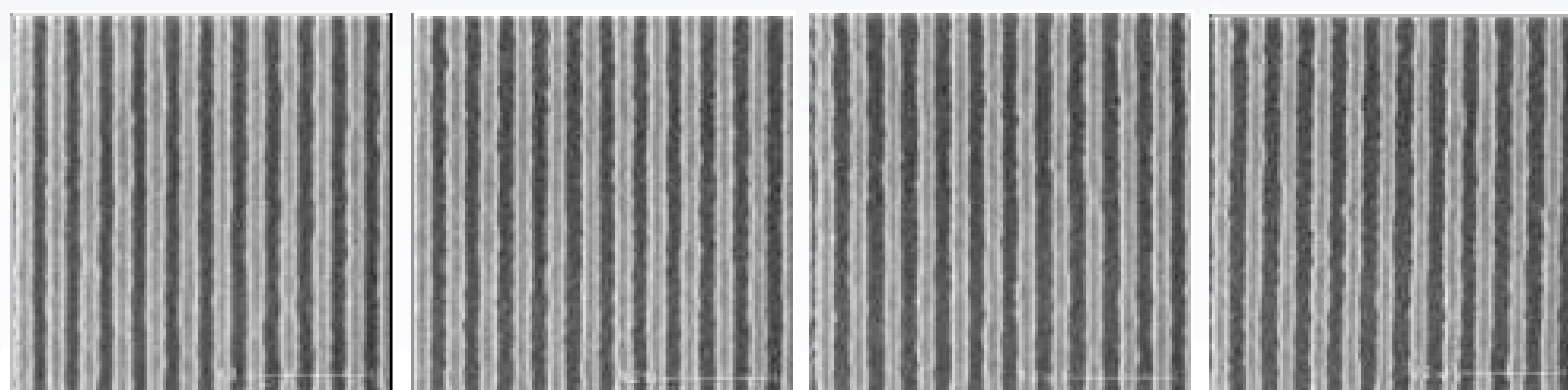
1. Z-Factor: The Evaluation Standard

$$\text{Z-factor} = (\text{resolution})^3 \times (\text{LER})^2 \times (\text{dose to size})$$

An EUV underlayer could facilitate using two approaches:

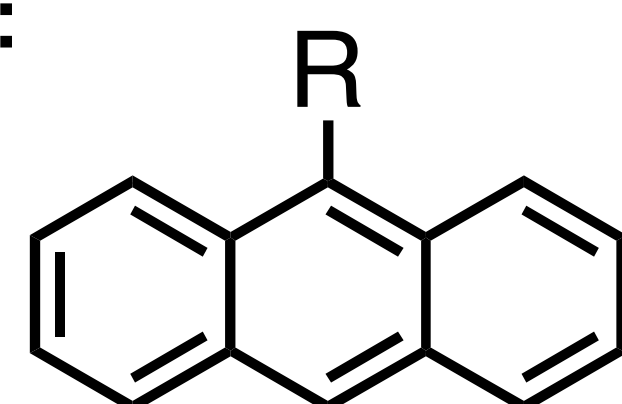
- More efficient energy harvesting and/or transferring to resist to increase photospeed
- Tuning underlayer chemical/physical structures or properties for higher resolution without pattern collapse

2. Photospeed Enhancement through Sensitizer

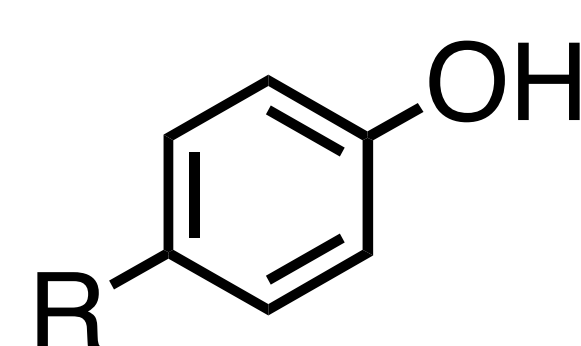


BSI.X09030C (Low Anthracene Load)	BSI.X07333 (Normal Anthracene Load)	BSI.X09030B (High Anthracene Load)	BSI.X09030E (High Phenol Load)
<u>Esize ~ 16.5 mJ</u> LWR ~ 4.6 nm UR ~ 26 nm DOF ~ 250 nm nZ ₃₂ ~ 7.2	<u>Esize ~ 14.0 mJ</u> LWR ~ 4.4 nm UR ~ 26 nm DOF ~ 325 nm nZ ₃₂ ~ 5.6	<u>Esize ~ 13.5 mJ</u> LWR ~ 4.6 nm UR ~ 26 nm DOF ~ 350 nm nZ ₃₂ ~ 5.9	<u>Esize ~ 12.5 mJ</u> LWR ~ 4.4 nm UR ~ 26 nm DOF ~ 325 nm nZ ₃₂ ~ 5.0

Anthracene:

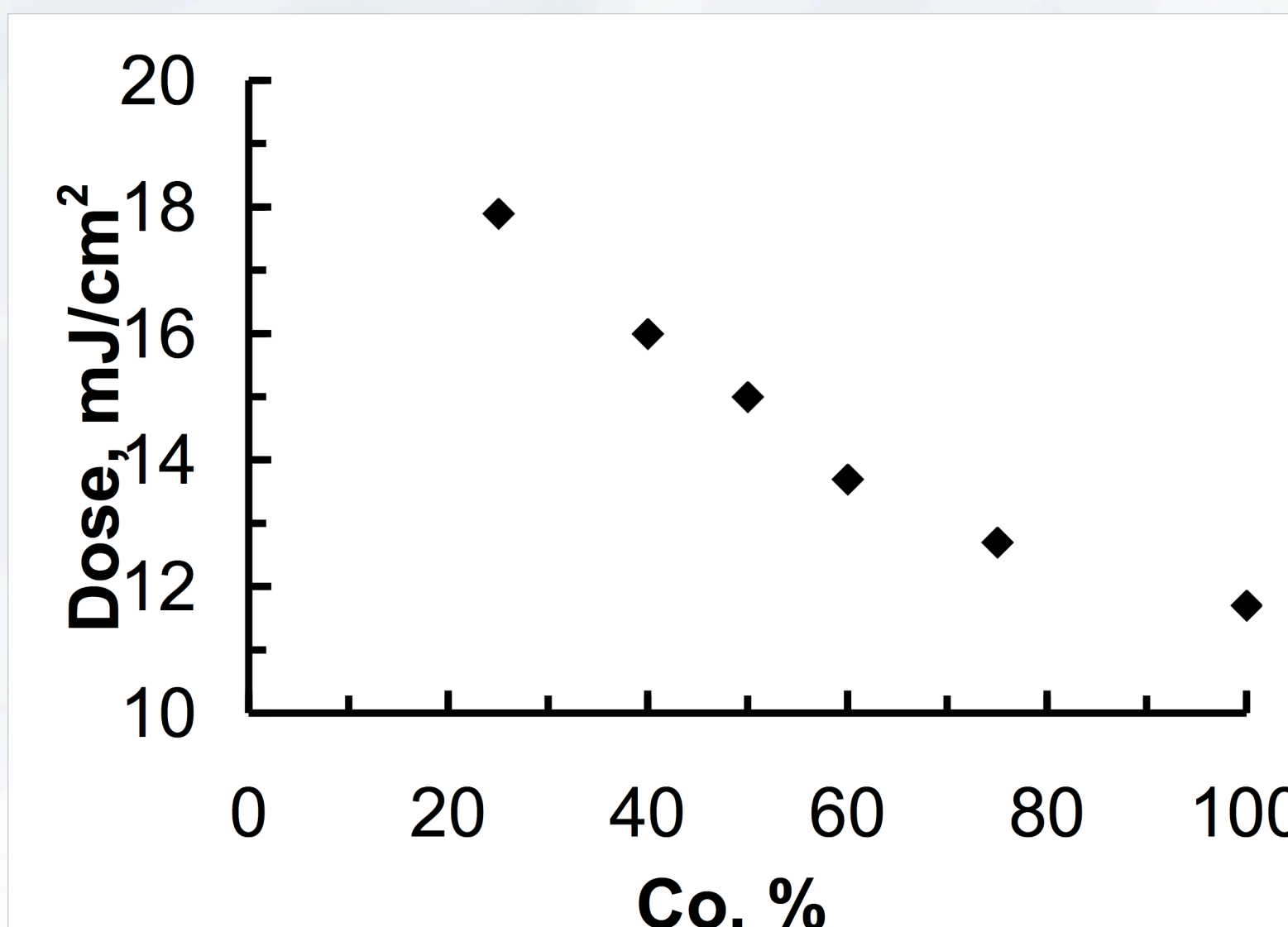
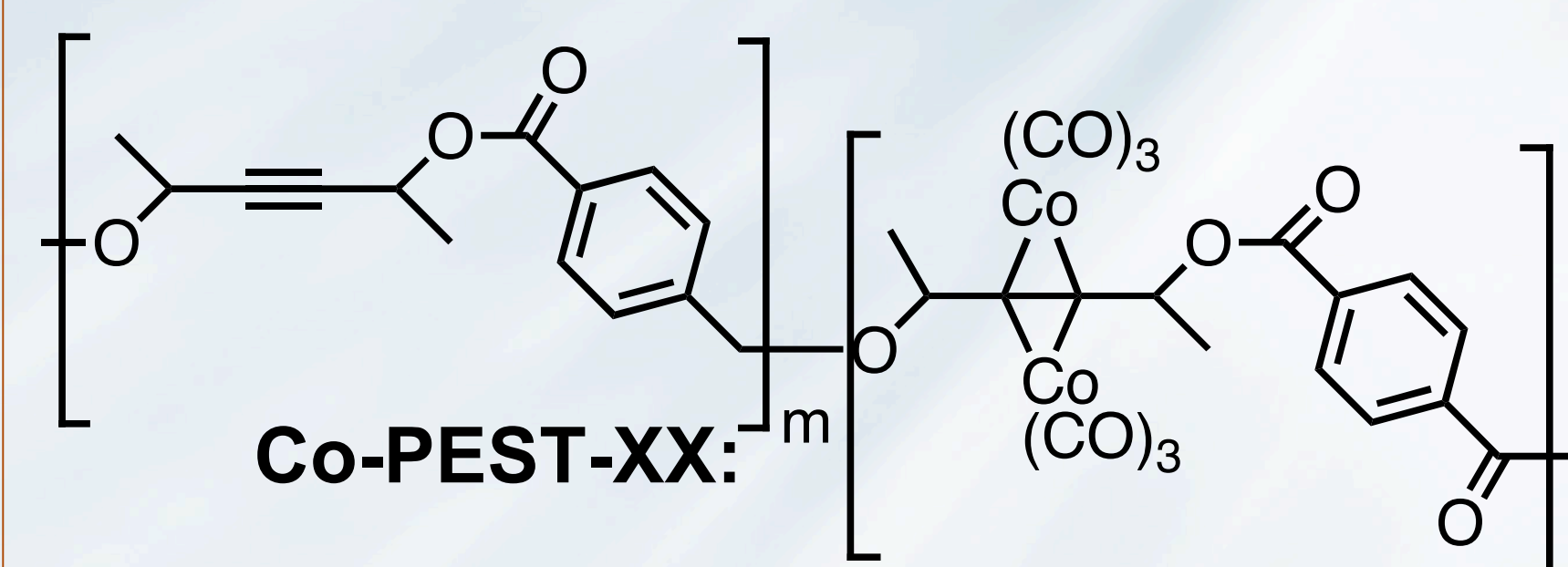


Phenol:



- Same **Resist C** was used in all cases; 30-nm HP images were acquired for comparison
- It is possible to boost the photospeed of the same EUV resist up to ~10%, without obvious degradation in resolution and LER, by using attached organic molecules that are believed to have energy sensitizing ability
- Sensitizer loading and type play an important role

3. Photospeed Gain through Metal Component



- Co-PEST-XX was synthesized using a standard polyester condensation reaction followed by co-ordination with $\text{Co}_2(\text{CO})_8$; “XX” represents the percentage of triple bonds that were functionalized
- TER60-AB, an open-source PHS type EUV resist, was used at ALS, Berkeley
- 60-nm HP images were taken to compare the dose to size with Co content (Co%)
- The dose to size decreased by as much as 30% with increased Co content

4. Preliminary Results on Crosslinker Loading

Crosslinker%:	Normal	High	Low
Molecular Glass Type	 LWR ~ 5.5nm	 LWR ~ 5.0nm	 Poor Coat Quality
Linear Polymer	 LWR ~ 4.3nm	 LWR ~ 5.0nm	 LWR ~ 5.0nm
Branched Polymer	 LWR ~ 4.3nm	 LWR ~ 5.3nm	 LWR ~ 5.7nm

- SERV-40 was used as the resist; 30-nm HP images were acquired for comparison
- It was found that an appropriate amount of crosslinker was needed to minimize LWR and to prevent pattern collapse
- This trend holds true for various underlayer platforms

5. Summary

- Organic energy sensitizers and metal components could increase resist photospeed
- Crosslinking density greatly affects LWR and pattern collapse